Topic: Origins, Acceleration and Evolution of the Solar Wind

Project Title:
Coupling electron and proton kinetic physics in the Solar Wind

PI Name: Tulasi Nandan Parashar
PI Email: tulasinandan@gmail.com
Affiliation: University Of Delaware
Project Information:
Science Goals: The mean free path of particles in solar wind is
~1AU or larger, making it larger than most scales of interest. This
implies that the solar wind is extremely weakly collisional. Lack
of direct inter-species collisions drives the system into a highly
non-equilibrium state where protons and electrons are not in a thermal
equilibrium. However a lack of collisions and thermal equilibrium between
different plasma species does not imply that the species do not affect
each other. Both species affect the evolution and kinetic behavior of
the other via electromagnetic interactions. However, which processes
and channels enable this interaction, and the resultant effects have not
gained much attention at all. It is our aim to develop a research program
that addresses this problem using a combination of spacecraft data and
kinetic simulations. The objectives of the proposal are: (I) Identify
the channels of interaction between protons and electrons, and their
relation to reconnection and turbulence in the solar wind (II) Identify
the effects of this interaction on kinetic physics of both protons
and electrons, (III) Create statistical surveys of correlations between
various physical quantities of interest such as relative species heating,
turbulence amplitudes, individual species temperatures, temperature ratio
of both species, solar wind speed etc. The fundamental goal is to create
a comprehensive knowledge base that can guide global simulations of
solar wind to improve the thermodynamic representation of these species.

Methodology: The project will employ both, analysis of spacecraft data as
well as kinetic simulations to address this problem. The strategy will
be two pronged: (I) use kinetic simulations to identify the interaction
channels between the two species, and quantify their roles. (II)
Use spacecraft data to perform surveys of statistical correlations
between various quantities of interest, and to identify specific
intervals of interest to simulate using kinetic simulation models.
For kinetic simulations, primarily fully parallel electromagnetic
kinetic code P3D will be used. Our team has used this code extensively
for studying turbulence and reconnection. For spacecraft observations,
solar wind data from Wind, ACE, Cluster, Helios, and MMS spacecraft will
be used. Single-spacecraft and multi-spacecraft techniques will be used
where appropriate. Our team has expertise in analyzing data from all
these spacecraft for various turbulence studies.

Proposed Contributions to Focused Science Team Effort: The interplay
of protons and electrons in a collisionless system is of interest on
its own at a fundamental level. However, the statistical correlations
found in this study will be important to empirically represent the
thermodynamics of protons and electrons in global models. A preliminary
attempt in this regard has already been made by our collaborator Arcadi
Usmanov by incorporating results from one of recent papers into his
global heliospheric model. Moreover, the insights gathered from this
study will help interpret and analyze data from NASA/ESA missions such
as Parker Solar Probe, and Solar Orbiter.

Relevance: The proposed study is directly relevant to LWS program
objective 1: "Understand how the sun varies and what drives solar
variability" and Focused Science Topic 2: "Origins, Acceleration and
Evolution of the Solar Wind". Understanding the interplay of proton and
electron kinetic physics is central to a better understanding of the
solar wind and its evolution. This study is also relevant to the first

science objective defined in the 2014 Heliophysics Roadmap for NASA: "Solve the Fundamental Mysteries of Heliosphere" by understanding not only the fundamental processes that energize particles, but also by enhancing our understanding of the role that magnetic reconnection and turbulence play in the evolution of the solar wind.

ROSES ID: NNH18ZDA001N
Duration:
Selection Year: 2018
Program Element: Focused Science Topic

Citations: